

*PRESENT ABSENCE: A WORK FOR STRING QUINTET*

AND LIVE ELECTRONICS

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*Present Absence* is a work that integrates electronic processing and live performance. It is approximately 20 minutes long and is divided into three movements. The movements are distinct from each other, but are related through various elements.

Incorporating electronic processing and live performance can be cumbersome. The primary objective of this piece is to use electronic processing in a manner that liberates the performers from any restrictions imposed by the use of electronic processing.

The electronic processing in the work is accomplished through the program MAX/Msp, a real-time digital signal processing environment. The patch that was created for this piece is called MOO-V. This paper discusses the both the technical details in the construction of this patch, and the aesthetic it serves.

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## INTRODUCTION

*Present Absence* is a work for string quintet and live electronic processing. The piece is approximately 20 minutes long, divided into three movements. The movements are 7, 8, and 5 minutes in length, respectively. Though each movement could be considered as a separate work, there are various relationships between them that provide coherence. The use of electronic processing and electronic sounds throughout creates a consistent aesthetic for the entire piece as well.

When I was deciding what material to use in *Present Absence*, I was influenced by other compositions. One of the pieces was George Crumb's *Black Angels*. This piece inspired me to write for the string quintet. The sound of the bowed glass is another influence from *Black Angels* that appears in *Present Absence*. The looping tape technique that Terry Riley pioneered in his works that appear on *A Rainbow In Curved Air* album is something that I wanted to include to exploit its possibilities for improvisation. I also wanted to explore the rhythmic complexities that result in the multi-layered texture of a feedback loop.

My primary concern in writing this piece was to utilize electronic processing in such a way as to facilitate integration with live performers and avoid a situation in which the aesthetic expression or musicality of the performers suffers from the possible limitations of electronic processing. This electronic processing was integral to the piece from its inception rather than composing for the instruments first and then creating the electronic processes that would accompany them.

Electronic processing is also one of the elements that characterize the overall structure of *Present Absence*. The level to which it is used varies from movement to movement. The employment of specific processes also changes throughout the work. Traditional structural elements are present as well. The first and second movement feature a rounded binary form and motivic development is vital in providing cohesion to the movements.

In order to better facilitate the interaction between acoustic and processed sounds, I examined the benefits and liabilities of real-time versus pre-processed tape music. Tape music has some advantages in the availability of some electronic processing, but real-time processing proved to be more responsive to live interaction, especially in terms of improvisational opportunities. Max/MSP is the programming environment I chose for the real-time sound processing. It is a flexible environment that allows for many different types of interplay between acoustic and processed sound. MSP also facilitates the use of pre-processed sound if desired.

Through the interaction of electronic processing, traditional compositional structures, and contemporary techniques, *Present Absence* is a work that seamlessly combines technology and live instrumental performance. Chapter one describes how several different musical elements relate through the piece. Chapter two is an examination of the benefits and liabilities of real-time processing as compared to pre-processed tape music, and chapter three describes the technical details of the Max/MSP patch that performs the electronic processing in this piece.

CHAPTER 1

STRUCTURAL ANALYSIS THROUGH FIVE

MUSICAL ELEMENTS

The compositional material and structure of *Present Absence* is derived from the development of several musical elements. These elements are rhythm, pitch, improvisation, minimalism and electronic processing. An analysis of these elements reveals the internal structures of individual movements and relationships that are developed throughout the entire piece. In addition, there are motivic ideas that link the movements together

The feature that differs most strikingly from movement to movement is rhythm. The rhythms of the first movement have a distinct beat or pulse for much of its duration. Downbeats are emphasized, and the measure is distinct if irregular. This movement maintains a polymetric feel throughout. A quick glance at the score will reveal the many triplets used. In general, there is a development of duple versus triple meter, first evidenced by the sound of the bass slapping the side like a percussion instrument in measure 6. Here the duple and triple meter are present in the bass as well as against the 'cello. This rhythmic juxtaposition eventually propagates to the other instruments, again in duple versus triple meter. In some measures, the dual meter is sustained long enough to necessitate multiple time signatures. At measure 61, the bass and 'cello are in 12/8, with the top three voices in common time. Similarly, at measure 107, the viola and 'cello are in 4/4 while the others remain in 3/4.

The second movement is not as driving as the first, but is more rhythmically complex. The measures are not as clearly delineated, becoming completely obfuscated in sections. This is due in large part to the prominence of multi-metered sections. In the second movement, the polymetric feel expands beyond duple versus triple meter. After the bass solo introduction and the ensuing homophonic section, the 'cello enters with a melody that does not follow any specific meter. The 3/4-meter used in this section is felt but not accentuated, and downbeats are often avoided or de-emphasized. The climax of this movement, at measure 150, presents the greatest number of concurrent meters: 12/8 in the 2<sup>nd</sup> violin; 3/4 in the viola; 8/4 in the 'cello; 4/8 in the bass with its accents; and 5/4 in the 1<sup>st</sup> violin when it enters. The electronically looped portions of this movement yield a similarly complex rhythmic pattern, which is caused by the manner in which the repeated material asserts its own meter. When a slice of time is recorded and then played back in a loop of fixed time, that time is heard as a meter. As sounds are added to the loop, the rhythms become increasingly complicated. This complication is further exacerbated by the fact that the beat of this looping playback may not be the same as the beat in use by the live performers.

The third movement is both the simplest and the most complex rhythmically. It is the simplest in that it uses only a few rhythmic patterns, but the pattern of the repeated melody results in complex rhythmic relationships. Two of the rhythmic patterns, the long tones played by the bass as a broken pedal, and the half-note rhythms at the end of the movement, are simple. The rhythm of the repeated melody is complex. It is in 7/4 or 14/8, depending on how it is felt, excepting the fifth measure. This measure is in 6/4 (which is why the movement as a whole is notated in 6/4) and adjusts the placement of



the beat by a half-step. When several instances of this pattern are present at the same time, the sense of a downbeat is lost until the rhythmic patterns synchronize, as they do at measure 23. The juxtaposition of the simple rhythmic ideas against the rhythm of the melody results in a greater sense of rhythmic complexity in the overall movement. As in the second movement, this effect is further complicated by the use of electronic looping and the return of earlier recorded events.

The only movement to contain improvised material is the second. In measure 78, the bass has a walking line that it repeats *ad libitum*. This material is fed into a tape loop and establishes the pulse of the section. The violins and viola improvise with one of three motives. The intent with this aleatoric section is to heighten the sense of a breakdown in an ordered, regular beat. Following the bass transition, the second movement is organized around order vs. chaos. The opening measures are comprised of highly regular rhythms and harmonic material. These progress toward chaos, their entropy culminating in the improvised looping sections. The other movements are more structured and do not allow for the freedom of improvised sections.

Pitch is used as an organizing element in all three of the movements. None use functional harmony, but the work exhibits pitch centers which act as points of departure. The first two movements establish pitch centers, move away from them, and return at the end. The third movement also returns to its initial pitch center. However, the center returns with a different motive, which contains slightly different pitch material. Movement one is centered around the pitch A, with quartal and quintal intervals prevailing. This harmonic character is firmly established with the repeating 'cello line of A E A. The other instruments enter with the same harmonic material, in differing

transpositions, and employ similar rhythmic motives. The center on A continues through measure 46, at which point the movement explores other pitch centers until the return to the opening material at measure 183 in the viola.

The overall organization of the material from measure 65 to 183 is an expansion of the four pitches presented at measure 67 (F<sup>#</sup>, F, B<sup>b</sup>, and A.) These pitches are developed both as a motive and as a harmonic structure. An example of their motivic use can be seen in measures 77 through 88. The violins play F<sup>#</sup> with the snap pizzicato. The viola follows with an F, C, and F, which is essentially an augmented statement of the beginning motive of the movement. The 'cello then plays the harmonic B<sup>b</sup> which is emphasized with the upper voices, followed by the bass and 'cello playing the A - E chord in measure 86. Measure 98 begins the presentation of these four pitches as a harmonic structure. The 'cello first presents the F<sup>#</sup> that is expanded upon by the upper voices. At measure 108, the viola takes up the F, which is harmonized with an F – minor triad and arpeggiated by the violins in measure 109 and forward. B<sup>b</sup> is presented in measure 126 and is prominent until the return of the A center, which is hesitantly brought back by the viola in measures 164 - 178. Here there is a homophonic restatement of the four pitches followed by a return to A at measure 183. To summarize, the first movement is based on a presentation of an A center, a departure from the A center using the pitches F<sup>#</sup>, F, B<sup>b</sup>, and A, and then a return to the A center brought forth by a harmonized version of the above four pitches.

The second movement also features the presentation of prioritized pitch material, movement away from it, and a return to the opening pitch center. The chords of measure 17 - 20 comprise the pitch area that is developed to the point of dissolution and then

brought back at the end. At measure 36, the violins and viola begin playing contrapuntal rather than homophonic lines. The pitches from the chords are present, but are first surrounded by neighbor tones. They progress to other intervals that shift the piece away from the harmonies of the introductory passage. Other pitch material in this movement includes the 'cello line which begins at measure 41. This is the melody from the third movement in altered rhythm and has no relation to the previously mentioned chordal material in measures 17 - 20. Measures 124 through 149 are a development of the half-step F<sup>#</sup> to G proffered as background material to the electronic looping and filtering. The climax at 150 through 189 uses yet another set of pitches, which are not related, but provide for a transition back to the chordal material in retrograde at measure 203.

The third movement does not share the rounded binary form of the first and second movements. Its repeated melody is drawn on the G major pentatonic scale. There are two transpositions of the melody, one on D and another on C. The displaced half notes at the end on the pitches G, D, and C do not present a return to the G pentatonic, due to the inclusion of the pitch C, but are a summarization of the transpositions. The B<sup>b</sup> pedal that re-occurs throughout the work in the bass provides color and enhances the sense of incongruity that a concurrence of non-related pitch material creates.

All three movements apply minimalistic techniques to some degree. Measure one of the first movement introduces the motive to be developed throughout the movement. The motive continues through measure 21 with occasional changes and modifications that are common in minimalistic gestures (Morgan 424-33). The motive undergoes a few changes in orchestration, such as in measures 33 – 46, where it is transferred from the bass and 'cello to the violins and viola, to end the piece at measure 183.

Measures 98 through 118 use minimalism differently. The bass has an eight measure theme that is repeated two and a half times, while the upper instruments go through two different sections that involve minimalistic repetition, one from measures 98 through 107, and another from 108 through 118.

The second movement also uses elements of minimalism. The repeated chords at its opening undergo a transformation. This process, described previously as one of order to chaos, displays the minimalistic technique of repeating limited material. Each repetition represents a slightly changed version of the previous. In this manner, little by little, the material is transformed.

Material is likewise repeated in the polymetric section that begins in measure 180, however, it is not altered with each repetition. The development in this section is accomplished by allowing the material to remain static so that the listener can explore the complex relationships between each of the layers. When the 1<sup>st</sup> violin enters, these relationships are further complicated by the presence of new pitches and different rhythmic material.

The improvised sections of the second movement are modeled after minimalist Terry Riley's experimentation with tape looping techniques. They are not allowed to develop as completely as Riley's did in works such as *Poppy No-Good and His All-Night Phantom Band*, but the principle is the same.

The third movement is also minimalistic. The melody of measures 1 –19 comprises essentially all the compositional material for the movement. The effects of the minimalistic techniques in this movement are a conflated harmony due to the different transpositions that occur simultaneously and a complex rhythmic summation resulting

from the eighth note displacement of the repetitions. In this manner, the melody comes in and out of phase with itself, similar to the tape piece *Come out to show them*, where Steve Reich explored the slight shifting of two repeated tape loops that gradually move apart and come back together.

The electronic processing (the technical details are described in chapter three) plays an important structural role. The amount of electronic processing and the use of pre-recorded tape music varies from movement to movement, but can be summarized as follows. The first movement includes various pre-recorded sounds and electronic processing (primarily tuned comb filters) and sample recording and playback of live sounds. The second movement makes heavy use of live processing, expanding the looping techniques used in the first movement. The last movement has less electronic processing but expands the use of the Doppler effect is in use throughout the entire work, and plays heavily on real-time spatialization.

*Present Absence* begins with a minute of pre-processed material. This is used to introduce several sounds that will re-occur throughout the piece. For example, the pre-processed bass and cymbal sound returns several times in the first movement. This sound is usually accompanied by the live bass playing three quarter notes followed by a dotted eighth note, which provides a transition between the various sections of the first movement. The first instance of this is at measure 22. Here the instruments build to a tutti statement of the movement's triplet motive followed directly by the change of texture brought in by the bass motive described above. This change makes room for the electronic processing, in addition to providing contrasting material. Two examples of

material that is recorded, processed and returned are the fall in the 2<sup>nd</sup> violin at measure 8, and the percussive section that begins at measure 47.

The most prominent use of electronic looping in the second movement begins at measure 76. The looping technique allows for improvisation and enhances the disordered feeling. Filtering techniques are employed here as well, but do not use specific tunings as in the first movement. Rather, the filters are set up here to create virtual sonic space for the music to flow through. In one instance, one side of the room sounds like a glass chamber and the other sounds like a rock quarry. In another, the size of the virtual space is changed so that the room can seem large at times, and the instruments sound far away or, the room size and aspect does not change and the virtual space sounds quite intimate and close.

The third movement also exploits the illusion of a changing environment. However, the changes are perhaps more subtle. Electronic processing is used to send pre-processed and live sounds through the performance space. This effect, which employs the Doppler shift, uses sounds from the beginning of the work and recorded material from the other movements, as in the fall or glissando of the violin and the percussive sections of the 'cello and bass described above. Looping techniques are adapted in this movement to thicken the texture and to amplify its polytonal aspects.

The five characteristics that have been described, i.e. rhythm, improvisation, pitch, minimalism, and electronic processing, develop throughout *Present Absence*. However, the individual movements do not rely heavily on the others for their *raison d'être*. The individual movements are linked together by motives. These motives connect the first and third movements the second. The bass introduction to the second

movement serves as a transition from the first. The triplet leaps are reminiscent of the first movement's dominant rhythmic character. It is not until measure 143 that there is another reference to the first movement. Here, as a passing gesture, the triplet motive with the fifth and fourth interval returns, transposed to C. In measure 150, the 2<sup>nd</sup> violin has a descending version of the motive that is again suggestive of the first movement.

The 'cello's theme at measure 40 of the second movement draws on the pitches from the first seven measures of the melody in the third movement. The rhythm is quite different, and the phrasing is obfuscated so as to create a relationship between the two that is not a simple reiteration (or in this case a pre-iteration.) This melody is brought back again with the return of the chordal material at measure 195.

Interactions between the movements that are not evidenced from a reading of the score involve the electronic processing. There are several ways that the electronic material creates relationships between the movements. The first has to do with the pre-processed sounds of the beginning. The guiro sound (a sound that was stretched via phase vocoding) is heard in each of the three movements, typically in conjunction with the Doppler effect. The return of recorded sounds is another manner in which the structure of the movements is created through the use of electronics. It is impossible to use live, sampled sounds from the second and third movements in either the first or, first and second, respectively. However, recorded material from the first movement returns in various forms in the second and third. The movements are also related in the consistent application of virtual sonic space.

*Present Absence* explores various possibilities of the five musical elements discussed above. The individual movements are separate, but there are relationships

between them that make the piece a cohesive whole. The employment of these elements was intended to create an overall aesthetic that is consistent throughout the entire work. The use of rhythm, for example, is different in each movement but is consistently polymetric. The electronic processes are used in different ways in each of the movements, but the same processes are used throughout. These musical elements best exemplify the this relationship of similarities and differences between the three movements.



## CHAPTER 2

### REAL-TIME PROCESSING VERSUS PRE-PROCESSED TAPE MUSIC WITH LIVE PERFORMERS

There were many pre-compositional decisions in the creation of this piece. One of the most important was the decision to use live processing versus a pre-processed tape that would accompany the performers. Real-time or live processing offers many possibilities that pre-processing does not. For example, pre-processed tape music does not allow for the same level of interaction with the live performers that can be achieved in real-time processing. An examination of live versus pre-recorded sound demonstrates why *Present Absence* necessitated live processing.

In terms of sound possibilities, pre-processing (or non-real-time production) has some advantages over live processing. This is due to a number of factors. One is the fact that pre-processing can make use of all the samples in a sound and does not have to process each sample individually (or each sample buffer as is often the case in real-time processes.) Another has to do with the specific time constraints inherent in real-time processing. The processes that are accomplished with tape music do not have these same constraints. A third factor involves the kinds of resources that can be brought to bear on sonic material. A sound to be processed could undergo several different procedures before it is finished whereas the number of procedures for a real-time-processed sound is limited by the computer cpu speed and memory available.

There are limitations with tape music as well. There can be little to no flexibility with the timing of the performance. While there can be some interaction with the tape part, this interaction is much more difficult to accomplish with pre-processed sounds than it is with real-time processing. This lack of interaction not only affects the fusion of the acoustic and electronic parts, but also severely limits the possibility of improvisation.

Processing the entire sound is a great advantage over having to process each sample or sample buffer. In tape music, one can take a sound and reverse it. This cannot be accomplished with real-time processing. If the ending material of a sonic event is not present, it is impossible to begin with it. This also applies to such techniques as reverse reverberation, where the 'echoed' sound precedes the impulse sound.

There are processes that use an analysis of the entire sound to produce an altered reconstitution of it. One such process is the program Cmix's 'gravy.' This process analyzes the sound, recording its pitch material and its non-pitched material and produces an averaging of the two at once for a specified duration. It is as if the sound is swirled in a blender and then poured out. (Thus the name.) This type of processing is again impossible with real-time sonic material, due to the lack of availability of the entire sound. Another process is non-linear granulation. A sound could not be broken into tiny fragments and then presented out of order unless the whole sound was there to begin with. Wave shaping in real-time is impossible unless there is some pre-recorded material present to serve as the index function. In general, any process that makes use of the entire sound at once in its processing, and any process that recreates the sonic material in a non-linear manner, is impossible with real-time processing.

If large sections of music are pre-recorded for manipulation, the sounds can be used in any order in the final piece. This makes it possible to foreshadow subsequent events in the tape portion. For example, sound material from the end of the work could be present throughout the piece. It could be altered in several different ways and then serve as a point of arrival when the live performer finally plays the same material. There could be a dialogue between tape and performer that uses entirely different material. Boulez takes advantage of this in his *dialogue de l'ombre double*. Where, in the transition between the first and second strophe, the tape portion, or "*l'ombre double*," creates a background for the live performer with tremolandi while the live portion plays flitting grace notes. At the end of the passage, the live performer joins the tape in the performance of the tremolandi. (Boulez 6)<sup>1</sup>

Tape processing allows for a sound to go through several different processes. The first process could be the detailed editing of source material. A composer has the ability to review the source material, take smaller portions of it to process, and then discard the remaining portions. Choosing one portion to manipulate, this sound could be stretched via phase vocoding. This stretched version of the sound could then be filtered to eliminate pitch material at a certain frequency. A fraction of the resultant stretched and filtered sound, could then be chosen for looping to create a rhythmic pulse. This looped sound would be altered in such a manner as to avoid the digital clipping that results from the splicing together of non-congruent samples. All of the above processes can be accomplished with real-time processes on their own (admittedly with some difficulty)

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<sup>1</sup> Although it should be noted that in this piece, Boulez uses real-time processes such as spatialization with sound diffusion as well.

but, it would be impossible to combine all of them.

One of the largest advantages that tape music holds over real-time processing is the ability to perform non-time dependant manipulation. Processors, whether they are computers or specialized hardware, must be incredibly fast to process live sound and recreate it without noticeable latency. This demand makes many of the electronic processes unavailable to real-time manipulations. Even though there have been great advances in microprocessors, there remains a large difference in what can be done in real-time versus what can be done with pre-processed material. An example of this can be seen in the process of convolution. It is possible to use convolution in real-time, provided one of the sounds involved has been pre-recorded. However, the limitations of the processor could easily result in digital distortion due to samples that have to be skipped in order to keep up with real-time performance. Phase vocoding (which also uses Fast Fourier Transforms or fft's) is another process that is computationally expensive. Again, there is hardware that will allow one to phase vocode in real-time, but the applications are limited in comparison with what is available to the tape composer. Once these processes are combined, the limitations become even more acute. For example, using phase vocoding and convolution at the same time is not possible for the vast majority of real-time composers due to the limitations of hardware.

Most real-time algorithms make use of a sample buffer to accomplish their processing. This buffer is used so the resultant processed sound is smooth without noise artifacts caused from a sample that the computer is not able to process in time. This buffer can also serve as an analysis frame for the computer to accomplish tasks such as real-time convolution and phase vocoding. The inherent issue with a buffer is that the

length of this buffer creates latency in the sound output. That is, the acoustic input into the real-time processor will be heard before the processed sound by at least as long as the sample buffer length. For processes such as delay, echo, or reverb, this is not a problem, but for others, it can result in undesired discontinuities.

While there are many possibilities for pre-processed tape composition, there are also liabilities in tape plus live performance works. When performing with a pre-recorded tape, the live performers become slave to the timing of the tape. There cannot be any flexibility with the timing of the piece if close synchronization is mandated by the score. This precludes such things as rubato, ritardandos, and accelerandos. The timing constraints of the tape work can be so demanding that live performers feel like simple machines, playing their pitches and articulations on demand with little or no ability to add their own musicality to the work. Many performers find this limitation on their expressiveness prohibitive and undesirable.

One of the main challenges of a tape plus instrument work is to blend the two different sounds together. If this fusion is accomplished with an action - reaction sequence between the tape and instruments, one is confronted with the difficulty of precise timing. The same is true if the tape and live performers present material at the same time. If a composer desires timbres from both the tape and the instruments that are similar, rather than contrasting, he or she is confronted with limitations intrinsic to recording and playback. This is further exacerbated if the pre-recorded sounds have been heavily processed. Sound emanating from a speaker, however good the speaker may be, has a different quality than sound that is produced by a live instrument. If the pre-recorded sound is recorded with a microphone very close to the instrument, it will pick up

sounds that are not heard by an audience in a live performance. Some of these sounds may be the mechanisms of the instrument working, such as valves or key being depressed, or condensation running through the instrument. These sounds, along with the presence of higher frequency partials that are normally filtered out over a distance, can make the tape sound as if it were up close, and thus place it in a very different sonic space than a live instrument. A composer may choose to exploit these qualities, but they distinguish a tape performance from a live one. This effect can be minimized with the use of microphones and reverberation, although, use of these devices constitute real-time processing (even if it is limited.)

Real-time processing has its own set of advantages and disadvantages. The greatest advantage is the influences performers can have on the processing of the sound. One of these influences can be the tone quality of the sound. If a performer uses a particular technique to produce a sound it is reflected in the resultant processing. For example, if a string player uses *col lengo* bowing techniques, the processed sound will share some of that ethereal, silvery sound that *col lengo* bowing produces. A brass player could employ a flutter-tongue, or multi-phonetic technique, or a flute player could 'over blow' a note to emphasize certain harmonics. All of these effects would change the resulting processed sound significantly.

Timbres of the live instruments can be changed with live processing. A flute can sound like a bass guitar, or a violin, or a mockingbird, or any combination. A small chamber ensemble could sound like a large orchestra.

Even simple dynamics could drastically change the real-time processing. This effect could be as simple as a shared dynamic in the processed and live sounds or, it

could be complex. A composer could develop a process that responds in very different ways depending on the volume of the live sound. Amplitude domain convolution is an example of this, where the volume of the live sound corresponds to the amount of the convoluted sound that is present in the final processed sound. Further exploitation of these techniques could involve triggering the processing of a sound using dynamic level thresholds, either soft or loud. In this manner, the performer can turn the processing on or off. This participation in the electronic processing is not available to the performer of a tape plus instrument work.

Another benefit of real-time processing is the absence of an autocratic timing mechanism. Performers do not have to adhere to an inflexible playback. This allows performers to speed up or slow down, as they feel appropriate. It gives them the ability to exert their own sense of expressiveness in much the same way they would in a piece that does not have any processing. In this situation, the electronics only enhance the performance.

Improvisation is much easier to facilitate in a real-time environment. While it is possible for improvisation in a tape piece, the duration would have to be fixed, and the tape portion could not react to the improvisations. If processing is accomplished in real-time, however, the duration could be as long as the composer cared to allow. Feedback looping techniques empower performers to improvise with themselves as the sounds are looped back into the mix. The second movement of *Present Absence* takes advantage of these techniques.

Spatialization techniques can move live sound through a performance space. A simple form of spatialization is manipulation of the diffusion, where fader levels on the

mixing board dictate which speaker or speakers the sound is played through. The fader levels can be pre-programmed so that complex combinations of speaker 'movements' can be achieved. If the movement of sounds through different speakers is combined with filtering processes, the illusion of distance is possible. The further away a sound is, the less one hears its higher frequencies. Thus if a low pass filter is applied to the sound, the psycho-acoustic phenomena of distance is re-created.<sup>2</sup> The sense of space is also a result of the time delays in the reverberated sound. Real-time processing can change the time of the delayed sound to create a larger or smaller sense of space. *Present Absence* uses a combination of all of these effects to create a sense of a virtual sonic space, and to move the live sounds through it.

Real-time processing can be configured to leverage some of the benefits of tape processing. In a real-time environment such as MAX/MSP, one can record a sound and process it during the live performance. This recorded sound can return in subsequent sections of the work. *Present Absence* takes advantage of this as well. Recorded and processed material from the first movement re-occurs throughout the entire piece. Through the use of recording and processing, one could exact a manipulation on a sound that is not possible in real-time due to the limitations of the hardware. However, if a composer chooses to manipulate pre-recorded material, most of the advantages of tape music could be employed in a real-time environment. Using live processes in conjunction with controlled playback, the enhanced processing capability of tape music would not suffer its intrinsic inflexibilities.

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<sup>2</sup> For a discussion of acoustic properties of sound see: *Fundamentals of Musical Acoustics* and *Physics of Musical Sounds*.



While real-time processing does allow for interaction with live performance, creating a program that listens to the performers to trigger events and processes is not trivial. The best way for a program to track the performer's progress through a score would be to detect the various pitches that are present. The program could then follow the score, and initiate processes or playback a recorded fragment of sound at any point along the score. Pitch-tracking technology is not always reliable. Programs that track the pitch of the performer, such as the MSP object `fiddle~`, often become confused, mistaking a strong harmonic partial for the fundamental pitch. The presence of several pitches at the same time further disorients the pitch tracking software.

Pitch tracking technology continues to evolve, and hopefully will provide a reliable way of synchronizing performers with the computer. Since this technology has not matured, composers must rely on other triggering paradigms.

One way to trigger events at the appropriate time would be with a timing mechanism. The program would launch events when its internal timer reached some time. This works very well, but has a large drawback. The performers must adhere to the timing mechanism of the program in much the same way they would have to adhere to the rigid timings of a tape piece. If this method is used, a great advantage of real-time processing is lost.

Another method to control the real-time processor would be to count events and keep track of their passage. The computer then would not need to know what pitches the performers were playing, it would simply count the number of notes that go by. This method is especially desirable if the sounds to be processed are percussive in nature and do not have definite pitches. There are difficulties that must be overcome with this

method, however. If the performer were to make a mistake (as humans are sometimes known to do) either missing a note, or playing one too many, it would throw the counting and the synchronization off. Describing the meter to the computer, and then instructing the program to only listen for each note to establish a beat could overcome this. Then, the program could simply count measures, checking from time to time that the performers have not changed the tempo. In lieu of tracking a change in pitch, the computer would have to be able to detect a separation between the notes. While this could be accomplished in some settings for one or two instruments, (provided they were not playing in legato, or worse, portamento style) it would become much too difficult to discern if there were many instruments playing at once.

Human interaction with the program could compensate for the difficulties inherent in the timing of real-time processing. If the piece used a conductor, he or she could manually trigger events in the score via some control mechanism. The mechanism would have to be designed to allow for some mistakes. If one used a simple footpedal that the conductor or one of the performers would tap at designated moments in the score, the mechanism would fail if one of the events was missed, or triggered too early. This could destroy the synchronization in the rest of the piece. Tracking the beat with a simple foot pedal provides another possibility. If the conductor, or one of the performers, taps their foot, the computer can keep track of the progression of meters without needing to detect a separation of notes. As with the manual triggering described above, the system must have tolerance for errors if the performer is not tapping consistently and accurately. Nonetheless, if the piece relies on a definite pulse this tapping method could be employed.

Due to these difficulties *Present Absence* uses a technician to perform the computer part, following the score and triggering each event with the flexibility to skip or to go back to an event. It was modeled after the solution used by Cort Lippe in his *Music for Computer and Hi-Hat* (1998), but adds the ability to choose a particular event. This is described in greater detail in chapter three regarding the technical details of the computer program.

*Present Absence* uses many processing techniques that are only possible in a real-time environment. The spatialization of live sounds, and the tape-looped improvisations of the second movement, could not be accomplished with pre-processing techniques. Where the limitations of real-time processing were prohibitive, playback of pre-processed sounds were integrated. The Max/MSP real-time programming environment in *Present Absence* exploits the advantages of both live and tape processing without suffering from their drawbacks.

## CHAPTER 3

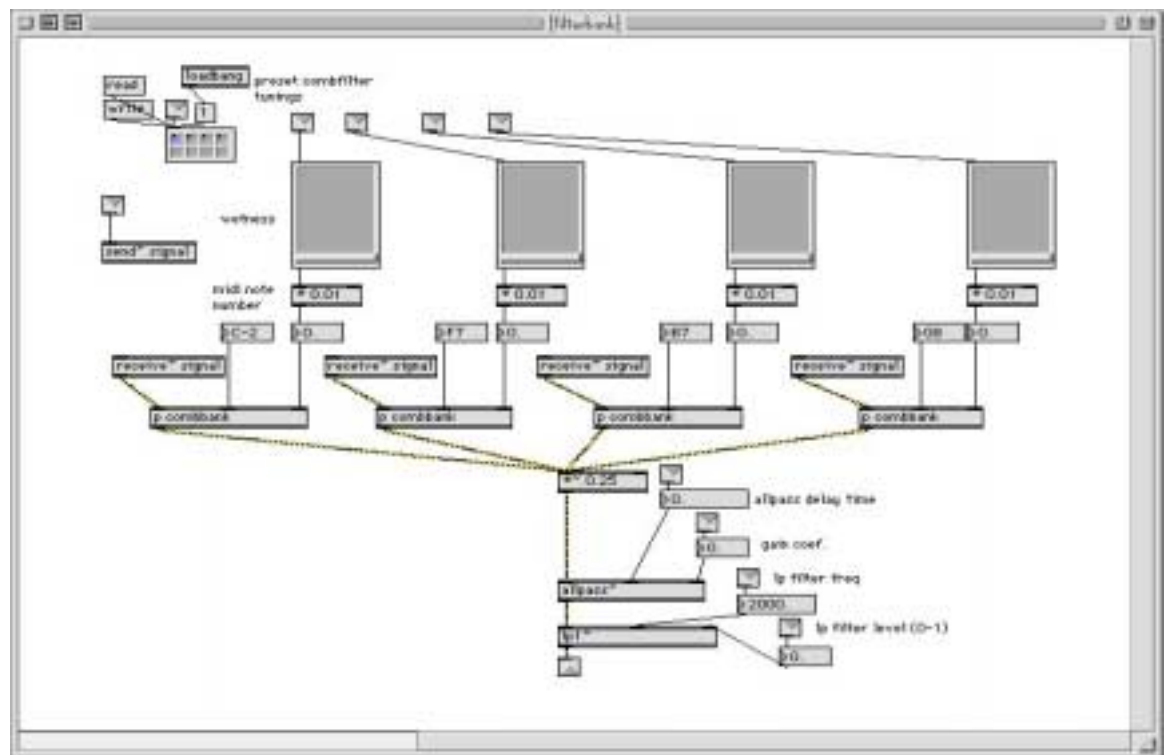
### THE TECHNICAL DETAILS OF MOO-V, THE MAX/MSP PATCH USED IN PRESENT ABSENCE

The decision to use a live processing environment with Max/MSP was the first pre-compositional choice for *Present Absence*. I decided to use a string quintet only after some of the patches were already developed. I wanted to use Max/MSP because of the possibilities it presents in live processing, and the ability to draw on its playback techniques to allow for the use of pre-processed material. The programming is primarily concerned with the concept of sonic space and how it can be recreated virtually in a performance setting. This programming included extensive work in developing a method to create the Doppler effect on both live sounds and for pre-recorded ones. This work included the development of numerous digital signal processing algorithms to emulate different acoustic environments. Finally, I wanted to program a looping-playback section to build layers of sound and to promote interactive improvisational possibilities. The Max/MSP patch I created is called MOO-V. It is divided into four main sections: one for creating the sonic space; another to move sounds through the space; a third for both the playback of the pre-recorded material and for the recording, processing, and playback of live material; and a fourth to control the entire patch in performance.

In order to provide the illusion of a space other than the fixed performance setting, it was necessary to decide which factors influence the psycho-acoustic phenomena of sonic space. I wanted to develop algorithms that could emulate

environments as different as the Grand Canyon or an apartment living room.<sup>1</sup> The factors I decided to concentrate on were reverberation, the delay timing of the echoed sound, filtering, and volume. Creating a virtual environment in MOO-V is accomplished through a patch called *delaysandfilters* and it has components that address each of these factors.

*The Computer Music Tutorial* describes Manfred Schroeder's method on how to recreate reverberation with electronic processing. (Roads 484) This is the model used by the patcher *filterbank*. For each of the two input channels, there is a bank of filters. This filter bank consists of four tuned comb filters, one allpass filter, and one lowpass filter (see image below).



<sup>1</sup> *Fundamentals of Music Acoustics* provides two chapters (11 and 12) on the discussion of room acoustics and *The Computer Music Tutorial* discusses the properties of reverberations in various acoustic settings in pp. 472-492.

### *The filterbank subpatch*

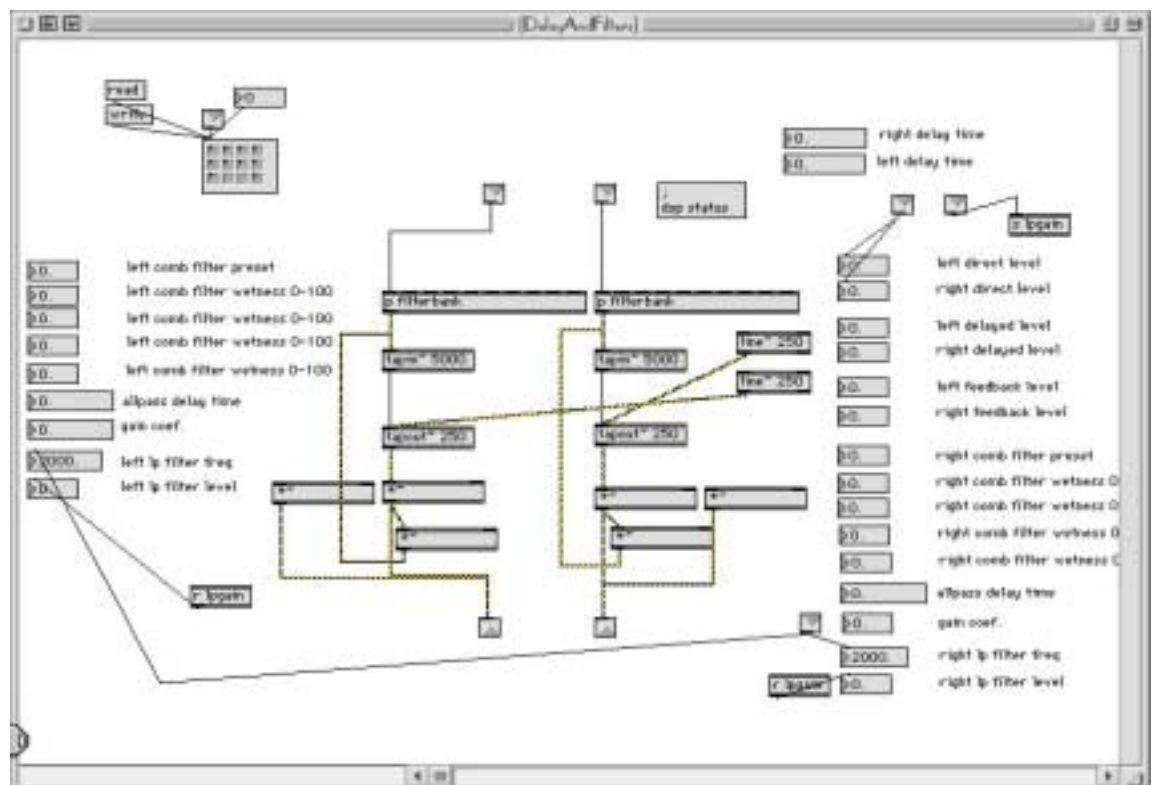
The four comb filters can be tuned independently, and have individual wetness controls. The combbank subpatch provides tuning of the comb filters by first converting the notes to frequencies, then inverting the frequency used and using the result as the delay time in the comb filter. Tuning the comb filter emphasizes the pitch it is tuned to and is similar to the resonance that occurs when one sings in the shower. The wetness controls the level of that effect. In natural settings, the reverberation is tuned by the volume of the reverberating space and the reflective characteristics of the surfaces. In general, the higher the pitch, the smaller the space, and, the more reflective the surface, the stronger the effect (Roads 484.) If these relationships are taken into account a natural sound is created. However, if these relationships are altered or exaggerated, a wide range of effects are possible.

*Present Absence* contains sections where the comb filters are tuned high with a great degree of wetness to create a glassy sound similar to the bowed glass section of *Black Angels*. In other places, they are tuned low to create a sound similar to what would be heard if one played directly into the sound board of a piano. Often, the comb filter tunings and strengths are different in each channel so that a sound is transformed as it is moved through the virtual space. The tunings also serve to enhance a change in pitch color. Movements one and three use this technique broadly.

The allpass and lowpass filters are used to aid in the creation of a virtual space. Both effect the sense of distance and size of the space. To create the sense of a large space, the allpass filter's delay time is increased. As with the comb filters, the allpass's gain control emulates the amount of reflective characteristics of a surface. For example,

to create a sound similar to that of a racquetball court, the gain control of the allpass filter is increased. A robot-like sound is created if the allpass filter is exaggerated by setting its parameters to extreme values. The lowpass filter controls the sense of distance. There are fewer high-frequency components in a sound that is far away than there are in a sound that is close. The lowpass filter is able to dampen the higher frequencies of a sound with varying degree. (Roads 482-4) The illusion of distance is enhanced as the amount of high frequencies that are allowed to pass through decreases. A lowpass filter applied without also reducing the output volume, however, simply results in a muffled sound.

When all of the different filters are combined, it is possible to alter both the type of virtual space one is in and the sense of how far away a sound is in that space. In MOO-V, these filters are aided by a feedback loop with variable delay time. The patch displayed on page 28 controls the filterbank subpatches and incorporates their output into the feedback loop. The various parameters for this patch are: right and left delay time, level of the direct sound, the level of the filtered sound, and the feedback coefficient. As the illusion of distance is increased, the delay time increases, the amount of delayed and filtered sound increases, and the amount of direct sound decreases. The feedback coefficient determines what percentage of the sound is returned back into the overall mix. The improvised sections of the second movement returns a large portion of the sound in the feedback loop to create a multi-layered texture. There are two instances of the DelayandFilters patch, one for use in the patch that moves the sound through the virtual space, and one to interact with the live performers.



*The DelayandFilters subpatch.*

The second section of MOO-V builds on the DelayandFilters subpatch by moving sounds through virtual space. This patch, called realMOOV, also emulates the effect

caused by a moving sound source. When a sound source moves toward a listener, the frequency increases, causing an increase in pitch. The reverse is true if the sound is moving away. This is referred to as the Doppler effect (Askill 20.) The point at which the sound moves past the listener, and thus changes pitch, is called a Doppler shift. The patch `realMOOV` takes two pairs of x,y coordinates and a time in milliseconds as beginning and ending points for the move and the time it takes for the sound to move between the points.

There are over 40 subpatches in use in realMOOV. The majority of these are used to calculate the various parameters involved in the Doppler effect. The subpatches



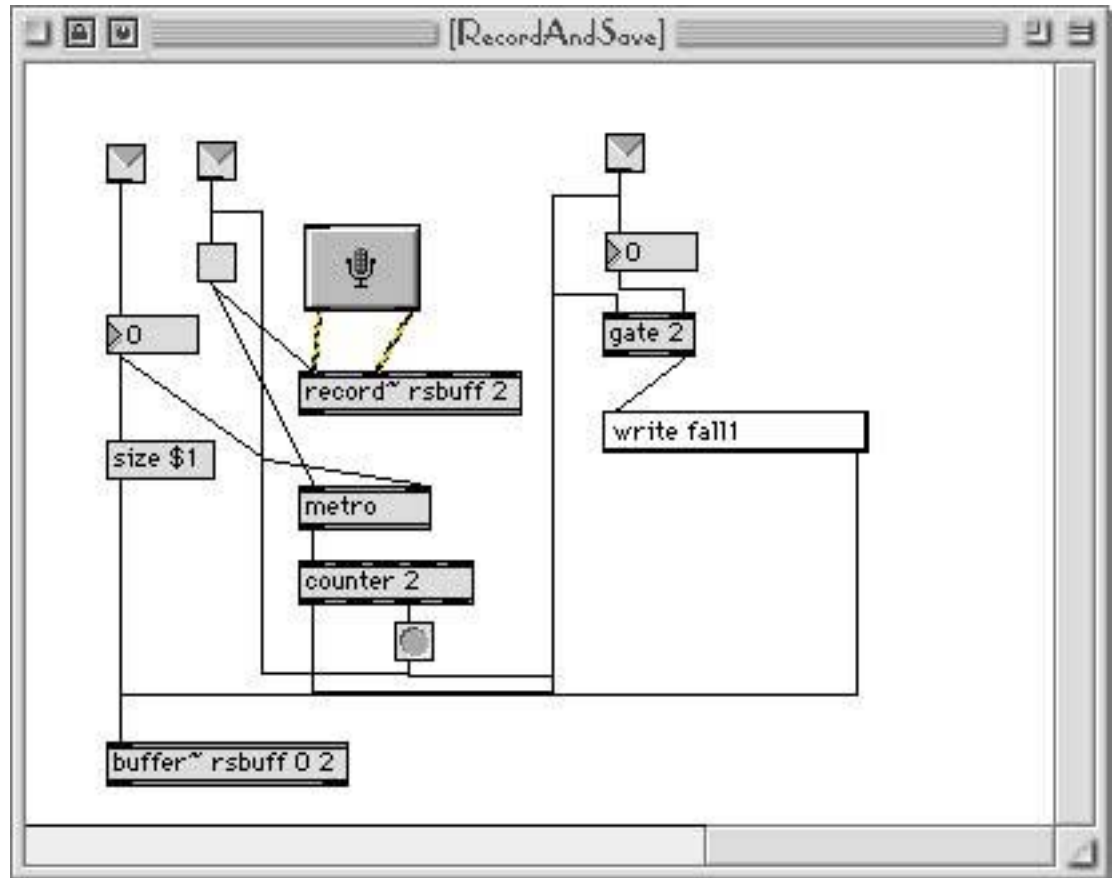


occur (the Doppler point) and a second line from the Doppler point to the final point. Velocities for each of these new lines are re-calculated and the Doppler effect (that is, the change in frequency) is implemented. The amplitude changes are calculated for each of the lines, and then the sound is played via a `groove~` object. The Doppler effect is best illustrated with the examples in the ensuing two paragraphs.

A move is to occur from a point three meters in front of and three meters to the left of the listener; x, y coordinate (3,-3) to a point three meters in front of and three meters to the right of the listener (3,3). The sound is moved over a period of 2 seconds or 2000 milliseconds. A Doppler shift in this move appears at point (0,3). This is the exact point where a line perpendicular to the trajectory made by connecting the points (-3,3) and (3,3). The sound is increasing in intensity as it travels toward point (0,3), and decreasing as it travels away. As long as the sound source does not accelerate, the change in frequency is fixed, thus, the frequency is higher as the sound travels from point (-3,3) to (0,3) and lower as it travels from (0,3) to (3,3). Thus the sound is initiated at (-3,3), having a higher frequency and increasing in intensity while it makes the 1 second journey to point (0,3). From there the point has a lower frequency, and a decreasing intensity as it travels over 1 second to point (3,3).

It is also possible that a moving sound will not have a Doppler shift. If a sound were to begin at point (1,1) and move to point (10,10) over a period of 5 seconds, it would not exhibit a Doppler shift and would not change frequencies. In this example, the sound would merely have a lowered frequency and decreasing amplitude as it traveled continually farther away from the listener at point (0,0).

In order to use the processes described above in the patch realMOOV, it is necessary to have a live sound recorded into a buffer, or to load a pre-processed sound into a buffer. The patcher RecordandSave accomplishes this task.



*The RecordandSave subpatch.*

This patch records for a pre-determined amount of time and then writes the sound to disk using a pre-defined list of file names. The buffer in use by the groove~ object is then changed to reflect the name of the sound file that is recorded by the RecordandSave patch.

The remaining portion of MOO-V controls how the other patches are used. Through the clicking of numbered message buttons, the user triggers events that are pre-

configured through the use of various preset objects throughout the patch. The 'presets' object receives the numbered message and in turn sets other objects in action to record a sound file; or to create a virtual sonic space; or to initiate a move sequence, or any combination of the above. The read and write features of the 'presets' object allow for the experimentation of several different parameter settings until the desired setting is discovered and recorded.

In the future, I would like to enhance the triggering mechanism. It would be preferable if a technician was not needed to click on the various message buttons to trigger events. Methods for automated triggering of events are complex and unreliable, as described in chapter 2, and influenced my decision to control the MOO-V patch is controlled by the message boxes. It may be possible to use a combination of the various automation techniques (i.e. using the footpedal, or counting events, or small scale timing, to achieve a reliable triggering function without needing another person to manually control the computer patch.) I plan to investigate these possibilities in forthcoming compositions.

MOO-V is quite flexible and offers many possibilities that could not all be explored in one work. This is especially true of the DelayandFilters subpatch. I will be employing this patch in various works to come, exploring the different virtual environments that MOO-V facilitates.

## CONCLUSION

*Present Absence* changed during the course of its composition. I had initially intended to use electronic processing in a graduated manner. The first movement was to have little processing, the second a bit more, and the third was to be completely improvised using the looping feedback and other real-time processing in MOO-V. I changed this idea because I thought the work needed a more structured conclusion that would be a fitting counterpart to the chaotic explorations of the second movement.

With the exception of this change, the bulk of *Present Absence* was realized with many of the pre-compositional decisions unaltered. The work uses minimalistic techniques as I had intended. The electronic processing interacts with the live performers. Similarly, the Doppler patch was implemented with most of the functionality that was projected at the outset.

The various influences for this composition are evidenced throughout the work. From Riley to Lippe and Boulez to Crumb, this piece uses many techniques and ideas of late twentieth century composers and expands on them. It is a blend of several different musical elements. It is atonal yet has pitch centers. It uses minimalism in sections but is not wholly minimalistic.

The structure of *Present Absence* is derived from various relationships. The first and second movements have a rounded binary structure in that they return to their opening material. The third movement is through composed but exhibits a return to the same tonal center that it began with. The three movements are related to each other with

motives. The second movement uses motives from the first and third movements to act as a common link that holds the entire piece together. Electronic processing is another structural element. The patches and electronic processing techniques are shared across the movements to yield a consistent sound throughout the work.

Perhaps the most innovative aspect of the composition is the use of spatialization techniques in conjunction with an implementation of the Doppler effect. While there are programs that will accomplish both tasks, such as VST pluggins for Digidesign's Pro Tools , there are few that will do so at the same time. The ability to draw on these effects in a real-time environment is certainly not wide-spread and was the main source of inspiration for the work.

Through its use of Max/MSP patch MOO-V, *Present Absence* provides a vehicle for the string quintet to interact with real-time processing techniques in a way that utilizes expanded instrumental performance techniques and embellishes their potential sound producing capabilities without being awkward or forced.

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CONDUCTOR SCORE

*PRESENT ABSENCE*



## Performance Time - 7:00

## Present Absent

for String Quintet and MAX/MSP

Jeff Bell

[illegible]



[illegible]

This musical score is for measures 26-31 of 'The Swan' from 'The Nutcracker'. It features five staves: Violin 1 (Vln. 1), Violin 2 (Vln. 2), Viola (Vla.), Violoncello (Vcl.), and Contrabass (Cb.).

- Measures 26-31:** The score is divided into two systems. The first system contains measures 26-30, and the second system contains measures 31-35. Measures 26-30 are marked with a box containing the number '6', and measures 31-35 are marked with a box containing the number '7'.
- Violin 1 (Vln. 1):** Plays a melodic line in treble clef. Measures 26-30 are marked *mp* (mezzo-piano). Measures 31-35 are marked *mf* (mezzo-forte).
- Violin 2 (Vln. 2):** Plays a melodic line in treble clef. Measures 26-30 are marked *mp*. Measures 31-35 are marked *mf*.
- Viola (Vla.):** Plays a melodic line in alto clef. Measures 26-30 are marked *mp*. Measures 31-35 are marked *pp* (pianissimo).
- Violoncello (Vcl.):** Plays a melodic line in bass clef. Measures 26-30 are marked *mp*. Measures 31-35 are marked *pp*.
- Contrabass (Cb.):** Plays a melodic line in bass clef. Measures 26-30 are marked *mp*. Measures 31-35 are marked *pp*.

The score includes various musical notations such as notes, rests, and dynamic markings. The key signature is one flat (B-flat major or D minor). The time signature is 12/8.

34

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

38

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

4:3

2:3

2

Violin 1

Violin 2

Viola

Violoncello

Contrabass

46

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

8

+ = strike by f hole with thumb  
- = slap the side

2:3

3:2



60

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

10

*pp*

65

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

11

*mp*

*ff*

*ff*

The image shows a musical score for measures 12 and 13 of 'The Swan' from 'The Nutcracker'. The score is for five instruments: Violin 1 (Vln. 1), Violin 2 (Vln. 2), Viola (Vla.), Violoncello (Vcl.), and Contrabass (Cb.).

**Measure 12:**

- Vln. 1:** Starts with a fermata on a half note G4. Then rests for two measures, followed by a half note A4 with a fermata.
- Vln. 2:** Similar to Vln. 1, with a fermata on G4, two measures of rest, and a half note A4 with a fermata.
- Vla.:** Rests for the first two measures, then plays a half note G3 with a fermata.
- Vcl.:** Rests for the first two measures, then plays a half note G2 with a fermata.
- Cb.:** Rests for the first two measures, then plays a half note G1 with a fermata.

**Measure 13:**

- Vln. 1 & Vln. 2:** Rests for the first two measures, then play a half note A4 with a fermata.
- Vla.:** Rests for the first two measures, then plays a half note G3 with a fermata.
- Vcl. & Cb.:** Rests for the first two measures, then play a half note G2 with a fermata.

The score includes dynamic markings: *ff* (fortissimo) for the strings in measure 12, and *mp* (mezzo-piano) for the strings in measure 13. The Viola part has a *13* marking above the staff in measure 12. The Violoncello and Contrabass parts are marked *Arco* (arco) in measure 12.

14

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp* *f*

*mp* *f*

*loco*

*f*

*loco*

*f*

*Pizz.*

*f*



95

15

8va

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp*

*p*

105

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

*mf*

*mf*

16

114

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*Arco*

123

*loco*

*pp*

*mp*

*p*

*mp*

*p*

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.



153

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*p*

163

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*p*

18

[illegible]

183 20 21

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

*mf*

The image shows a musical score for five instruments: Violin 1, Violin 2, Viola, Violoncello, and Contrabass. The score is divided into measures 183-210 and measures 20-21. The key signature is one flat (B-flat), and the time signature is 12/8. The Viola part is marked *mf* and features a continuous eighth-note pattern. The Violin 1 part is marked *mf* and features a melodic line with a trill in measure 21. The Violin 2, Violoncello, and Contrabass parts are marked with a whole rest in measures 183-210 and a whole note in measure 21.

187

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

191

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp*

*mp*

*2:3*

*2:3*

*2:3*

*2:3*

196

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

Detailed description: This system contains measures 196 to 200. Vln. 1 and Vln. 2 play a half note G4 in measure 196, then rest. Vla. plays eighth notes: G4, A4, B4, C5, B4, A4, G4. Vcl. and Cb. play a rhythmic pattern of eighth notes: G3, A3, B3, C4, B3, A3, G3. The dynamic *mf* is marked at the start of measure 197. The key signature has one sharp (F#) and the time signature is 12/8.

200

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

Detailed description: This system contains measures 200 to 204. Vln. 1 and Vln. 2 play a half note G4 in measure 200, then rest. Vla. plays eighth notes: G4, A4, B4, C5, B4, A4, G4. Vcl. and Cb. play a rhythmic pattern of eighth notes: G3, A3, B3, C4, B3, A3, G3. The key signature has one sharp (F#) and the time signature is 12/8.

204

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

208

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.



## Mvt. 2

1

2

Violin 1

Violin 2

Viola

Cello

Bass

*Solo Freely*  
*Pizz.*  
*mf*

*3:2*

*Accel.*

*f*

*ff*

*3:2*  
*Rit.*

3

4

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*Arco*

*p*

*f*

*3:2*

*Rit.*

*tr*  
*p* (*b* *o*)

*3:2*

*ff*

*mf*

5 6 7

When loop fades, continue

♩ = 106

13

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*ppp*

*ppp*

*ppp*

21

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*p*

*mp*

*mf*

*f*

*ff*

8

32

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*fff*

*fff*

*fff*

*p*

*p*

*p*

*mf*

43

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

*mf*

53 *Pizz.* 9

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*Pizz.*  
*mf*

3:2

63 10

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*colegno*

3:2 3:2

3:2

71

4:3

*f*

*f*

*ff*

6:4

3:2

3:2

3:2

3

3:2

3:2

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

11

78

Play a, b, and c in any order ad lib. until delay fades (approx. \_ sec.)

Play a, b, and c in any order ad lib. until delay fades (approx. \_ sec.)

Play a, b, and c in any order ad lib. until delay fades (approx. \_ sec.)

*Pizz.* repeat ad lib.

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

12

play pitches in any order, any rhythm ad lib.

*colegno batutto* -----,

play pitches in any order, any rhythm ad lib.

*colegno batutto* -----,

play pitches in any order, any rhythm ad lib.

*colegno batutto* -----,

88

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

repeat ad lib.

98

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

in time

play a, b, and c in any order ad lib.

in time when cello begins

*colegno*

mp

126

14

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

*f*

*mf*

*f*

*mf*

*f*

*mf*

*f*

*colegno*

*mp*

*f*

134

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp*

*mf*

*mp*

*mf*

*colegno*



141

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mf*

*mf*

*mf*

*mf*  
*colegno*

*mf*

3:2 3:2 3:2

3:2 3:2 3:2

3:2 3:2 3:2

3:2 3:2 3:2

3:2 3:2 3:2

146

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

15

16

*mf*

*mf*

*mf*  
*Pizz.*

*mf*

*mf*

3:2 3:2 3:2 3:2

3:2 3:2 3:2 3:2

[illegible][illegible]

[illegible]

Violin I (Vln. 1) plays a melodic line with a fermata at the end of measure 169. Violin II (Vln. 2) plays a rhythmic pattern of eighth notes with a 3:2 ratio. Viola (Vla.) plays a rhythmic pattern of eighth notes with a 3:2 ratio. Violoncello (Vcl.) plays a rhythmic pattern of eighth notes with a 3:2 ratio. Contrabass (Cb.) plays a rhythmic pattern of eighth notes with a 3:2 ratio.

17

18

175

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

3:2 3:2 3:2 3:2

3:2 3:2 3:2 3:2

181

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

3:2 3:2 3:2 3:2

3:2 3:2 3:2 3:2

19

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

189

20

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

199

*ppp*

*mp*

*mf*

210

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*f* *fff* *fff*

# Mvt. 3

Performance Time - 4:00

1

Violin 1

Violin 2

Viola

Cello

Bass

*mp*

2

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp*

*p*

3

13

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp*

*mp*

*mf*

*f*

Detailed description: This system contains measures 13 through 18. Vln. 1 and Vln. 2 have whole rests for most of the system. Vla. and Vcl. play a steady eighth-note accompaniment. Cb. enters in measure 13 with a low, sustained line. Dynamics are marked as *mp* for Vla. and Vcl., *mf* for Cb. in measure 16, and *f* for Cb. in measure 17.

4

5

19

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*mp*

*mp*

Detailed description: This system contains measures 19 through 24. Vln. 1 and Vln. 2 play a melodic line. Vla. and Vcl. continue the eighth-note accompaniment. Cb. has a low, sustained line. Dynamics are marked as *mp* for Vln. 1, Vln. 2, and Cb. in measure 24.



25

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*f*

*p*

31

6

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

*pp*

*mf*

*f*





60

Vln. 1

Vln. 2

Vla.

Vcl.

Cb.

This musical score shows measures 60, 61, and 62 for five instruments: Violin 1, Violin 2, Viola, Violoncello, and Contrabass. The key signature has one flat (B-flat), and the time signature is 3/4. Violin 1 and Violoncello/Contrabass play whole notes. Violin 2 plays eighth notes with slurs and ties. Viola plays whole notes with a fermata in measure 60. The score ends with a double bar line at the end of measure 62.